W. Brian Arthur is a professor at the Santa Fe Institute. Formerly a professor at Stanford University, he holds a Ph.D. from Berkeley, and has graduate degrees in economics, engineering, and mathematics.

Arthur's main research interests lie in theorizing about the economics of the high technology sector. He is best known for his study of positive feedbacks, or increasing returns -- in particular their role in magnifying small, random events in the economy. He is the author of *Increasing Returns and Path Dependence in the Economy*.

His ideas have attracted increased public attention with the recent antitrust investigation of Microsoft by the U.S. Department of Justice. Joel Klein -- Assistant Attorney General, and head of the antitrust division that is investigating Microsoft -- recently singled Arthur out as a theorist who has particularly influenced his thinking on high-technology markets.

His work on increasing returns won him a Guggenheim Fellowship in 1987 and the Schumpeter Prize in Economics in 1990. He is a consultant to Citicorp and McKinsey and Co, and a Fellow with Coopers & Lybrand.

At the end of April, as the Microsoft case approached a new climax, Professor Arthur gave an interview with PreText magazine editor Dominic Gates. For the first time in a public forum he spoke extensively about his theories, his critics, and the Microsoft case.
"Increasing returns makes economics a cheerful science."

His Economic Theories: Increasing Returns and Path Dependence

U.S. Department of Justice versus Microsoft

Answering Critics of his Theories

Academic In-Fighting in the Media

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His Economic Theories: Increasing Returns and Path Dependence

Gates: What are increasing returns and how do they work?

Arthur: Increasing returns are a form of positive feedback: the tendency of anything that's ahead in market share to get farther ahead, or if something's falling behind in market share to get farther behind.

Gates: Is this a general mechanism in economics?

Arthur: Yes. It's a body of economics that's exactly parallel to diminishing returns in neoclassical economics. It's the twin concept. Say you've seen many, many movies in a month; sooner or later you've exhausted the ones that are matched for your taste; so you're running into things that are not so good. In industry, if you expand your business beyond a certain degree, it's always been held that you run into increasing costs or declining clientele, or increased hassles. You run into diminishing returns.

By contrast, very often in high tech as something gets farther ahead it gets more and more advantage. If many people are using Java, then people like me feel they have to install Java instead of, say, ActiveX. If a product gets further ahead it gets further advantage. If that's so, you say there are increasing returns.

The fact that there are increasing returns is wonderful news. If something gets better, as it's more used, this is great news; if something gets cheaper the more it is produced, that's wonderful. Diminishing returns made Carlyle call economics a dismal science. Increasing returns maybe makes economics a cheerful science.
**Gates**: There does seem to be a confusing proliferation of words to describe several closely related economic ideas here, so I'd like to define some terms. What is path dependence, and what are network effects?

**Arthur**: In high tech there are three very particular mechanisms that make for increasing returns. One is up-front costs. Because high tech products are extraordinarily complicated to design, there are often very large up-front R&D costs; $200 or $300 million for Windows 95 for example. That's the first disk. And then the second and third disk out the door cost Microsoft only a few pennies.

Another effect is what I call customer groove-in. Sometimes it's just called learning effects. As you use something that's complicated, you come to know its foibles. And the more I type on the QWERTY typewriter keyboard, the better I get at that. It's harder for me to switch over to some alternative keyboard. The more an airline knows how to use, maintain, and fly Boeing aircraft, the more likely they are to order from Boeing. This seems to be very much a high tech thing, because it's hard to learn a high tech product. So the more I use Microsoft Word, which I do use, the more locked in I am or grooved-in to Microsoft.

[Then there are] network effects, sometimes called network externalities. In a nutshell, if nobody has a telephone, the telephone isn't much used; but if everybody has a telephone, or say e-mail, then it is much more useful. It's another form of positive feedback. If everybody is using Java, then more applications are going to be written for Java. It's the positive feedback that comes from a network of users.

**Gates**: And path dependence?

**Arthur**: Imagine there are increasing returns in the market with several products, all competing: Microsoft Money versus Quicken, or ActiveX versus Java. They're competing and then one of them gets ahead. If there's enough increasing returns there, as any one of them got ahead it would get further advantage.

When you have increasing returns, at the outset markets are unstable and lurch back and forth according to different small events, and then lock in to one of many possible outcomes. What locks in is a function of what happened in history. The outcome in increasing returns markets depends on
small events along the way. The shorthand for that is "path dependence." Meaning that small events along the way decide the outcome.

The U.S. presidential primaries are very path dependent. Depending on who gets ahead, there are increasing returns. Candidates who look more presidential attract more money; if they have more money, they get more television time; with more television time, they're more likely to look like a presidential prospect. The outcome is decided by the pathway the whole process has taken through Iowa and New Hampshire.

Gates: Once you start down one path, whatever it is, it's hard to go back.

Arthur: Yes. It grooves - in a path. If rain falls on top of a sandy mountain, pretty soon it'll groove a pathway down the mountain and small events at the start will determine the topography and what rivers eventually form. It's important to note that the outcome is not completely determined by what's best. The outcome is partly determined by who gains what advantage when.

**U.S. Department of Justice versus Microsoft**

Gates: How did you become a player in the Justice Department case against Microsoft?

Arthur: In 1990 I published an article called "Positive Feedbacks in the Economy" in *Scientific American*, which was noticed by many people. One of them was Gary Reback [the lead lawyer representing several of Microsoft's corporate rivals, including Netscape and Sun]. When certain companies in Silicon Valley were filing a white paper against the acquisition of Intuit by Microsoft - - I think in the fall of 1995 -- Reback contacted me and asked me to take part in that. Actually, by then, I thought the case had a lot of merit. I was happy to be part of that.

And it seems further that that early paper of mine in *Scientific American*, and some of my other early papers, appear to have influenced people at the Justice Department -- notably Joel Klein -- and many others in academia and in the American legal system.

So when Microsoft became an issue, these sets of theories that I and other economists had been responsible for were what people started to reach
for to make sense of those markets.

I would be pretty clear that these are theories of how those market operate; they're not theories of whether Microsoft is good or bad. Microsoft itself has used increasing returns theories to justify its position -- notably by saying, "Isn't it better to have a single standard?" Increasing returns theories are in no way against Microsoft. They have to do with how the markets operate. Both sides, the Department of Justice and the Microsoft lawyers, are obviously going to build their case upon how those markets operate.

**Gates**: Since that initial white paper, have you been actively involved in the Justice Department case against Microsoft? Do you anticipate a further role?

**Arthur**: I have been in conversations with the Department of Justice, but I am not directly involved. Once in a while I run into someone like Nathan Myhrvold; I'm not involved on the Microsoft side either. I describe myself at the moment as an observer: I'm extremely interested in the case, but by choice I've stayed on the sidelines simply because I wanted to write and think rather than be flitting back and forth to Washington.

**Gates**: So if you were called to give evidence, would you turn that down?

**Arthur**: Oh, I'd rather not make any statement on that. I think it would depend on where and when and so forth. Let me just not answer that. But you can certainly ask me my attitude to the case.

**Gates**: OK, let me ask that then. What do you think of the case, the Justice Department's case against Microsoft?

**Arthur**: First of all, I think that monopoly in high tech is not necessarily a bad thing. Monopolies are inevitable in high tech given that there are so many sources of increasing returns. But they are short-lived, temporary monopolies.

The important thing for the consumer in high technology is that innovation continues at a reasonable pace. [Because] you can achieve a product monopoly in high tech, if you're lucky you can go from being a graduate student one year to being worth half a billion dollars after an IPO three years later. This has acted as a very powerful
incentive to innovate. Locking in the market becomes a prize for innovation.

I definitely think that the Department of Justice should not necessarily try to inhibit firms in the industry trying to lock-in this or that market. And by the way, the Department of Justice agrees with that.

What worries the Department of Justice, and also what would worry me, is if someone achieves a lock-in and then uses that unfairly in another market. The metaphor I've been using is that these markets are a little bit like the land rushes in the 1880s, in Oklahoma or Kansas. Everybody starts off with their horses and buggies behind the same line. [But in high tech] there's only one prize: you take 85 or 90 percent of the market.

Now imagine if you had won three or four of these races in succession and you parlayed your winnings into buying a Toyota Landcruiser instead of a horse and buggy. And just to make doubly sure, you hobble everybody else's horses at night. Well then I think that is cause for alarm.

To summarize my viewpoint, I think that the spotlight in high tech ought to be on two things that sometimes conflict: innovation and fairness. It's like the wild west in high tech at the moment. It's a wild and woolly and wonderful industry, like Dodge City or Tombstone in the 1880s, where anything goes and there's very little law. There's a huge amount of innovation and not that much regulation. The very idea that if you're lucky you can achieve a lock-in and get very seriously wealthy, that appears to have done wonders for innovation.

However, if these markets get very heavily locked in by a single firm for a long time, that appears to impede innovation. The fact that DOS had such a heavy lock on the operating system market for PCs meant that Microsoft didn't have a terribly strong incentive to innovate. It did indeed take them about 10 years to come out with a decent version of Windows.

The spotlight should be on innovation; achieving monopolies can be a prize for innovation. On the other hand, if one firm starts to monopolize everything, competitors can get scared out of the market and the dominant firm can have very little incentive to innovate. The right question to ask, in my opinion, is how is innovation affected?
And then the second question to ask is, what is competitively fair? It's not competitively fair to take over, say, 60 million users in Windows or 120 million or whatever it is, and then lever them onto your version of the Internet versus somebody else's. The Justice Department is right to be worried about that.

So yes, you can have a monopoly. But unfair use of the previous monopoly in a new market is not right. And again, I'd say that if you've won five races in a row, you can't just parlay that into winning the next five. It's healthier if everybody has a decent chance.

**Gates:** Well, if Microsoft is trying to do as you're suggesting, do you see Bill Gates as commanding a new evil empire?

**Arthur:** [laughs] No, I don't think it's an evil empire. There is healthy competition and then there is unfair competition. I think the evidence is steadily mounting that Microsoft has over the years crossed the line many, many times.

**Gates:** So do you think high tech needs to be regulated by the government?

**Arthur:** I think the government needs to do what is necessary to maintain innovation in the market and to maintain fairness. I think it's an extraordinarily tricky business to try to regulate in high tech markets, because they're moving and changing so rapidly.

I would not say that the government should want to regulate a specific market so as to try to influence outcomes or pick winners. On the other hand, I do think we need some rules of the game, just as there are rules for rugby or ice hockey.

I actually think that that's what's going to happen over the next five to ten years, especially because this Microsoft case is likely by precedent to set down a lot of the rules for high tech.

**Gates:** You mentioned Assistant Attorney General Joel Klein. In a *New Yorker* article, John Cassidy quoted Klein as singling you out as an economist who had greatly influenced his thinking about the way in which high tech markets operate. Cassidy went on to quote Klein as saying that "surgically applied [government] intervention" is desirable.
Do you have faith in the surgical application of government power?

**Arthur:** [laughs] Well, like most economists, I believe in free markets. I'm not alarmed that increasing returns spell doom to the capitalist system. However, I do think that there should be rules of fairness. What the government needs to do is to set down rules of the game for fairness and rules that preserve innovation.

I'm not sure that even if it wanted to the government could go into particular high tech markets and regulate how the outcome should be. And in fact, I'm not sure that's what their intention is either. As far as I can see they are not going to rule out the notion of monopolies.

But certainly there should be rules against what you might call night maneuvers -- maneuvering or scheming in a pernicious way and not competing fairly. And sad to say, there has been unfair competition in the software industry and in high tech in general, and I do think that rules need to be laid down as to what is fair. And enforced.

And again, more generally, we're leaving a period where the dominant pattern in the economy is bulk processing of steel, and automobiles, and cement, and heavy chemicals, and lumber, and so on. We're entering the era of high precision and fast moving high technology. All the rules of the game are written for this bulk processing era. The rules need to be rewritten for high tech. I would imagine they're going to be slightly different.

But as an economist, I would certainly lean towards minimal government intervention; and I lean toward allowing monopolies in high tech -- at least the smaller, temporary kind -- because those are the incentives to get rich and to innovate.

And then, if there are monopolies that are simply not playing fair, I would go after them. No question.

**Gates:** Cassidy's *New Yorker* article, which is very flattering to you, also had an interesting quote from Supreme Court Justice Learned Hand, who wrote "The successful competitor, having been urged to compete, must not be turned upon when he wins." That's a persuasive sound bite against too active an antitrust stance. Do you think that applies to Microsoft?
Arthur: No, I don't think so. I don't think that Microsoft is being taken to court because it's a winner. In fact, a large proportion of the American public and politicians revere Microsoft and Bill Gates simply because they've been winners.

Microsoft's being taken to court because it's felt that it's making unfair use of its monopolies. I think it's up to the government to prove it; my hunch is that there will be a lot of evidence in favor of that proposition.

I think that the people at the Department of Justice, the ones I've talked to, are certainly sophisticated about that. They're not going after Microsoft because it's Microsoft, or because it's highly visible. They don't want to see precedent set in high tech that lock-ins can be levered from one market into another. Or that the smaller, weaker competitors can be hobbled.

Gates: Another aspect of antitrust actions is the reality of legal procedures. The famous example is the IBM antitrust investigation, which took years, sapped corporate energy and money, and went nowhere. That raises the question of whether these cases are a feeding frenzy for lawyers and counterproductive in many ways.

Arthur: Yes, this is an element sometimes in these very large cases. Any legal system can provide nutrition for lawyers for many, many years. Cases like this should be brought reluctantly. But in the case of IBM, or the Bell phone system, or Microsoft, the public does have a right to find out whether their productive resources are being used efficiently and fairly.

Gates: Whose productive resources?

Arthur: The American public's resources. The productive resources of the country in the hands of Bill Gates or IBM. The public has a right to know from time to time if these monopolies are behaving efficiently and fairly. And from time to time large monopolies are going to get dragged into court to be probed. But, the answer to the IBM question is, if someone's brought into court and found innocent of murder, does that mean we shouldn't have any more murder trials?

Gates: Is antitrust intervention what moderates and makes acceptable the operation of market capitalism?
Arthur: No. Not at all. There are laws and institutions and stock markets, and then there's a tiny hair on the tail of the dog that is antitrust policy. It's one among many institutional backings to capitalism, that's all. And for the most part, it's never evoked. Competition goes on every day and there's very, very little intervention on an antitrust basis. But once in a while, large companies are called to Washington to justify what they've done. That's as it should be.

**Answering Critics of His Theories**

Gates: Is the theory of increasing returns still controversial?

Arthur: Absolutely not. This is now completely taken for granted in Silicon Valley. I don't have to go around California telling the Marc Andreesens of the world or the Andy Groves of the world that there are increasing returns. Intuitively, the smart people in high tech knew this all along.

Gates: Do you think Bill Gates realizes this?

Arthur: Absolutely, and has done for a long, long time, independent probably of any academic theories.

I don't know anyone who would describe themselves as a market capitalist, as a typical business person, who would find increasing returns threatening. On the contrary, what we're finding is that these are a body of theories that resonate very deeply with their own intuitions. Folks at Sun Microsystems, or other places, are using these theories. Sun used my theories to launch Java. In return they gave me a high end Sun workstation.

And all the academic battles about increasing returns were over around 1990. That's when the controversy stopped over whether it was correct, and the controversy started as to who had thought of it first.

Gates: So you don't see these ideas in opposition to classical economic theories, the Chicago school?

Arthur: Not at all.

However, some people who are great proponents of Chicago neoclassical economics seem to get uptight every so often in the opinion pages of the *Wall Street Journal*. The source of the problem is that if I
say that markets can lock in to one product or one company, not necessarily the best, then that's taken as a threat to the whole ideology of capitalism.

The only controversies are ideological ones. I think it's inevitable that any important theory, or any new theory of any importance, does have a trail of flat-earthers behind it, a trail of creationists; people who won't get it and don't get it, for one or other ideological reason.

So there is a rearguard battle being fought between academic economists and, how shall I put it, capitalist ideologues. Two or three years ago the Economist magazine, which can be quite ideological, seemed to be negative towards these ideas. Now it is no longer denying any of this.

Gates: And the Wall Street Journal?

Arthur: Well, the Wall Street Journal itself has story after story of increasing returns and the dynamics of these market. Only the opinion page of the Wall Street Journal is a lagging indicator of economic thinking.

Gates: So these theories are no threat to capitalism?

Arthur: On the contrary. Markets operate according to diminishing or increasing returns. Those are just like the laws of physics. Markets operate the way they do. Capitalism is a structure that's built on top of those markets, and it seems to me that standard capitalism of the sort that we have now does very well indeed under increasing returns.

But it does tend to make [the more] highly open capitalistic markets, as there are in high tech, seem to be somewhat more unstable. People in high tech know that you can lock-in a market almost before it starts. I don't think that is a threat to capitalism, but it makes for a less leisurely capitalism. And it makes for maybe more intense competition.

Gates: Let's talk about some of your critics. Stan Leibowitz and Stephen Margolis have written a critique, which was published on the Web site of the Libertarian Cato Institute and was the subject of a recent story in the Wall Street Journal. They claim to debunk the historical basis of path dependence theory, specifically the famous
QWERTY story [that the familiar QWERTY arrangement of the keys on a typewriter was deliberately designed in the 19th century to slow typists down, because early manual typewriters tended to jam. Once typewriter manufacturers were locked into QWERTY, an alternative design that allowed faster typing failed to supplant it.] Leibowitz and Margolis call this story a "fable" and the Wall Street Journal refers to it as an "urban legend."

Arthur: It is perfectly demonstrable that we are indeed locked into a single QWERTY keyboard. There are legions of examples of lock-in. I'm not sure even Margolis or Leibowitz would deny that.

Gates: Right. But what they were saying was that it wasn't an inferior technology that locked in, and that the historical story which claimed it to be so was simply not true.

Arthur: It's absurd to think that any theories of increasing returns hinge upon whether QWERTY is better or worse. That is nonsense.

If you shine the appropriate light on it, you could demonstrate that under certain circumstances something that locked in -- like QWERTY -- wasn't so bad after all. I don't know anybody who is saying QWERTY is wonderful, but it's not clear to me that QWERTY is that great.

Take another example in the Wall Street Journal article: Microsoft DOS. I know of no independent computer scientist who thinks that DOS was a wonderful operating system, even when it was produced, though you can find ingenious ways to show that it was in some strange sense superior.

Gates: Well, they claimed that DOS beat out Apple because it was cheaper.

Arthur: One can take anything that locks in and at the time it locks in, normally it's better; that's why people are buying it. It's more convenient, or it's out there, or it's what you run across. But the point is that there could have been something else that might have locked in that, in the long run, may well have been better.

Not so long after DOS came out, the Macintosh [operating system] was demonstrably better. I think that Microsoft itself has acknowledged that fact by designing Windows to look just like it. And if
people are saying, "Yes, but DOS was cheaper", well, think of all the wasted hours trying to use the damned thing. In computer science circles, DOS was a joke.

As far as I can see, the Leibowitz and Margolis arguments are ideological arguments for the far right. I don't see that there is a debate on increasing returns. You can have a debate as to whether what locked in might, under certain lights you shine on it, actually be better than what was locked out. You can make a case that gasoline engines are better than any alternative could have been. But frankly I don't know how to settle that, because you're talking about what might have been versus what is.

**Gates**: These theories are often discussed via particular examples or counter examples. One that you have cited is VHS versus Beta Max. Leibowitz and Margolis say that there was a good reason why VHS won: VHS tapes could record longer. And so, there was a reason why it locked in; it's not an example of path dependence.

**Arthur**: It is an example of path dependence.

The question of whether the product at the start was better or worse is moot. Yes, people may adopt VHS because it has a longer recording time. But the point of increasing returns is that if it gets ahead it locks in. Not what is better or what is worse. That's only a point for ideologues and the back pages of the *Wall Street Journal*.

**Gates**: But isn't an important part of your contribution your pointing out that things that get locked in aren't necessarily the best? It's not just to demonstrate lock-in, but to demonstrate lock-in of something that wasn't good for consumers.

**Arthur**: Well, again, you only get excited about that if you belong to the right wing of American ideology.

This notion that the market is always wonderful and perfect is a right-wing ideological idea. People don't expect that all the friends they have are the most optimal friends. People get married; sometimes it's wonderful and sometimes it isn't. Lock-ins occur; sometimes for the best, sometimes not.

The theory doesn't say that what locks in has to be inferior. The theory says that it's not necessarily
superior.

Gates: That same Wall Street Journal article concluded that there is "an emerging consensus . . . that the path dependence school has yet to come up with the smoking gun it needs to show the market-place locked into a manifestly inferior technology."

Do you have a smoking gun for increasing returns?

Arthur: I find I'm puzzled by all of this because it's a bit like debating evolution with creationists: "But if you believe in evolution, the inference is that angels must have evolved their wings, and that would upset all of theology." For me it's moot. The onus isn't on me or anyone else, to show that we're locked in to any inferior thing. The onus is on the opinion page of the Wall Street Journal and the libertarians to show that all things that we're using in the economy are not just the best they could have been at the time, but are the best that could possibly have emerged. Nobody in computer science believes that about DOS. As for the QWERTY keyboard, if Margolis and Liebowitz can prove it's the best, my hat is off to them.

Gates: Let me throw at you some more of these free enterprise think tank critiques of your theories. Clyde Wayne Crews went beyond saying that lock-in to inferior goods was a myth; he claims that lock-in is a myth. The examples he cited were: color TVs did supersede black and white; CDs did replace vinyl records. In another piece, Robert Levy of the Cato Institute, added a couple more examples: Word Perfect once looked unassailable as a word processing product; Lotus 123 once had no competition in spreadsheets. All of those actually failed to lock in and exclude the competition.

Arthur: Not at all. They all locked in, but then the next wave of technology took over. We were indeed locked in.

The fact is, technology comes in waves. No one I know who talks of increasing returns says that lock-in is forever. We are locked in to English, temporarily. In 500 years time it'll be a different language. Three-hundred years ago people were locked into Latin as the international means of discourse. No one said a lock-in is forever. In fact, it's taken for granted in high tech that lock-ins typically last anywhere between a year or two and five years.
Let me give you a very specific example here again. Netscape, as you know, had a heavy lock-in in the browser market. And it wasn't dislodged by means of a new wave of technology: no new software product came along to supplant the browser; instead it was steamrollered aside by the Microsoft juggernaut, Internet Explorer.

**Gates**: But it hasn't exactly been steamrollered out of the way. It still actually has a bigger share of the market than Internet Explorer.

**Arthur**: Well, you can certainly claim that its lock-in isn't as heavy as it was two years ago. I'm just saying that a lock-in is only good until the next wave of technology, until the game changes. And even if the game doesn't change -- it didn't with the browser market -- if you have enough guns, you can dislodge the lock-in.

**Gates**: Isn't lock-in just another word for standardization? Britain and the U.S. drive on different sides of the road. Wouldn't it be better if they both drove on the same side and you only had to make one kind of car? Similarly, the European Union has a single cell phone standard and the United States has three incompatible technologies.

What's wrong with standardization?

**Arthur**: Increasing returns are about the dynamics of markets. If a market locks in to something, it's not necessarily the best; on the other hand, as you were saying, there may well be advantages to locking in to a single standard. So any theories of increasing returns aren't necessarily pro- or anti-Microsoft. Under increasing returns, you can lock into a single standard and that might have enormous advantages.

Judging the pros and cons of increasing returns markets is case specific. Let me give you one example. If a market, say, software, locked into a single standard, say, Microsoft Windows/Explorer, you could argue that there's some advantage to that. It would be like having a single railway gauge all the way from Calais to Moscow a hundred years ago, so you didn't have to change trains at each border.

So my answer is yes, there are many advantages to increasing returns, and certainly one of them is that we can use a certain standard. Basically the entire Internet is the result of a telecommunications/computing standard: TCP/IP.
The existence of that standard made the World Wide Web possible. So yes, there are advantages in standardization.

Increasing returns are in a particular industry. They're either present or they're not. I want to get my point very clear on this. Increasing returns have to do with how markets work. Whether that is good or bad is somewhat case specific.

**Academic In-Fighting in the Media**

**Gates**: [MIT economist] Paul Krugman, is in some sense also a path dependence theorist. One might expect him to be on your side. What did you make of his attack on you a few months ago in *Slate*?

**Arthur**: I think it says that these theories of increasing returns are well accepted, and now the fights are not over who's right or wrong, but who said what first.

I don't want to leave the impression that all of this came out of nowhere in the 1980s; it had quite an ancestry. Economists have bandied about the ideas of increasing returns for over 100 years. Some of the really great economists, such as Alfred Marshall in 1891, had asked the question: instead of diminishing returns, what if firms gained an advantage the more market they took? I didn't invent increasing returns any more than Paul Krugman did.

But until my work in the early '80s, increasing returns was a static subject. Economists were aware that different outcomes were possible, with one or other product locking-in to market dominance. What was missing was a theory of the dynamic process by which market lock-ins take place. I supplied that theory, and did it rigorously, using modern, nonlinear probability theory. I have a series of articles and a book about that. This brought a greater awareness of dynamic labels and terms such as path dependence and lock-in. As far as I know, I was also the first person to claim that this had a huge area of application in high technology.

As I see it, Krugman's attack is his attempt to rewrite economic history, to stake claims and write in a very minor role for me. My attitude is, let history be the judge. What I've said is in writing, and the dates are marked; and what he said is in writing.
Krugman is a good economic theorist, and Paul is somebody I've been talking with for many years. It's a shame now that there are fights over precedence and who said what. Paul and his friends have done excellent work on international trade theory under increasing returns, and some newer work on regional economics under increasing returns. But they did not do anything about the dynamics of lock-in or small events being magnified.

I think Paul should just keep his hair on and do what he does. He's very good at it.

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